Product Development Team
for
NEXRAD Enhancements

Quarterly Report – 4th Quarter FY 00

00.6.1 Damaging Winds

Development and enhancement of the Damaging Downburst Detection and Prediction Algorithm (DDPDA) to ensure that it meets the aviation communities' needs for the prediction and detection of damaging winds associated with both wet and dry atmospheric environments, along with larger scale downbursts.

a) Current Efforts

As of the third quarter, Milestone 00.6.1.E1 is complete. OSF funding provided the opportunity to finalize DDPDA adaptable parameters and an evaluation of algorithm performance (currently underway).

The additional, OSF-funded work included analysis of additional cases (Table 1). Seventy-five other tapes from the NSSL level II tape library were also examined to determine if they would be useful as null events for DDPDA scoring. Most of these did not contain convective radar echoes, or had other limitations that prevented their use.

The entire, newly expanded data set was used to develop and test four different downburst prediction equations. This data set consisted of 100 severe downburst-producing cells and 1308 cells that did not produce severe downbursts. Linear discriminant analysis was use to develop downburst prediction equations on part of the data ("dependent" or "training" data set) which were then tested on the remaining cells ("independent" or "validation" data set). The goal of developing several different data sets for training and validation was to determine the spread of skill scores and discriminant coefficients.

The full data set was randomly split into two parts, with 65% of the data going into the training data set and the remaining 35% into the validation data set. This process was repeated four times, resulting in four different training and validation data sets, and therefore four different prediction equations. The skill scores for these four equations are shown in Table 2.

It is notable that, although there is some spread in Heidke's Skill Statistic (HSS) for the training and validation data sets, all of the HSS scores indicate that all four equations show significant skill in predicting the onset of damaging winds at the surface. One oddity in these data is that the skill scores show an improvement in the validation data set over the training data set. This was not

Table 1: Additional DDPDA Cases

Radar	Date	Events	Cells
KIWA	99/07/13	0	6
KIWA	94/07/17	0	12
KMLB	96/08/04	0	12
KTBW	95/07/14	0	11
KIWA	93/07/03	0	3
KIWA	94/07/18	0	14
KMKX	99/07/23	8	114
KDMX	99/07/02	1	15
KDVN	99/07/23	3	75
KLOT	99/07/23	3	197
KLOT	99/07/21	2	99
KIWA	99/07/14	2	89
KIWA	99/07/10	1	24
KIWA	99/07/07	2	29
KIWA	99/07/06	2	26

expected, and points to the necessity of expanding the data set to include more cases.

b) Planned Efforts

Begin transfer of DDPDA to Open Systems Platform (contingent upon the release of CODE 1.0).

c) Problems/Issues

None.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

Milestone 00.6.1.E1 is complete.

Table 2: Skill statistics for four DDPDA prediction equations on four different training and validation data sets.

	Hits	*Misses*	*False Alarms*	*Correct Nulls*	*POD*	*FAR*	*CSI*	*HSS*	*Lead time*
Training Set 1	23	33	25	837	0.41	0.60	0.25	0.34	5.0 min
Training Set 2	17	41	16	869	0.29	0.48	0.23	0.27	2.6 min
Training Set 3	27	31	26	851	0.47	0.49	0.32	0.44	4.3 min
Training Set 4	29	33	17	833	0.47	0.37	0.37	0.49	4.0 min
Validation Set 1	19	23	9	426	0.45	0.32	0.37	0.48	4.9 min
Validation Set 2	22	20	6	402	0.52	0.21	0.46	0.62	5.7 min
Validation Set 3	19	23	18	398	0.45	0.49	0.32	0.41	5.8 min
Validation Set 4	14	24	9	434	0.37	0.39	0.30	0.37	3.9 min

00.6.2 Polarization and Frequency Diversity

Continue development of algorithms that utilize polarization data to detect and predict the movement of the volumetric extent of hydrometeors such as hail, rain, snow, sleet, icing conditions, and freezing rain that are hazardous to aircraft.

a) Current Efforts

Hail Classification Algorithm (NSSL): Hydrometeor classification is determined by both temperature range, and temperature thresholds within those ranges. The effect of the temperature ranges and thresholds on the ability to identify rain/hail mixtures is studied. If a particular polarimetric signature is observed within a given range of temperatures, various hydrometeor types are assigned a probability. WIthin a given range, various thresholds are used to eliminate certain hydrometeor types from consideration. These temperatures are derived either from model output or in situ observations.

If the rain/hail mixture is lofted upwards by an updraft, it should be evident in Z_{DR} above the freezing level (the “Z_{DR} column”, Fig. 1). Typically, when hail in the absence of rain is considered, Z_{DR}~0 dB for small sizes and can be –0.5 to –2. dB for large hail. A rain/hail mixture is different, and may have Z_{DR} values

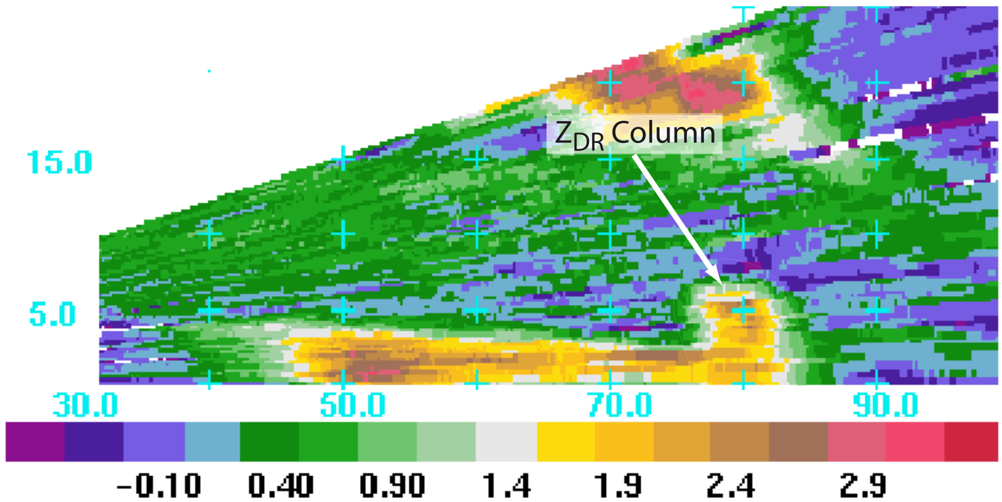

Figure 1. A ZDR column is shown by the arrow, at a range of 80 km. The data come from the the NSSL Cimmarron radar.

anywhere from pure hail (<0.5 dB) to as high as rain. Hence, the rain/hail mixture can be differentiated from pure hail or graupel/small hail mixtures. Recently completed work shows that adjusting the temperature range and lowering the threshold by 5^{o}C, from –10^{o}C to –15^{o}C, allows this rain/hail mixture to be identified a few hundred meters higher with Z_{DR} in data gathered with the NSSL Cimmarron radar on strong convection in Oklahoma. However, further reduction of the threshold made no further improvements. These changes did not affect data gathered by the NCAR S-POL radar in Florida, which is typified by weaker convection. So far, only these two cases have demonstrated usable Z_{DR} columns. Work on the use of spatial continuity has been started and will be continued.

(NCAR): Efforts with polarimetric radar included investigations of icing events which occurred on 14 September 1998 in Florida during the PRECIP98 field experiment and in Italy on 4 November during the MAP experiment. Analysis of designations made with the hydrometeor discrimination algorithm under testing revealed a capability to detect super-cooled raindrops in convective situations and an ability to detect some mixed- phase conditions with potential for icing. Portions of this work were summarized in a paper entitled “Aircraft icing detection using S-band polarization radar measurements” (Ellis et al. 2000) presented at the Ninth Conf. on Aviation, Range, and Aerospace Meteorology.

Another key activity was the development and testing of an algorithm for the automatic detection of the freezing level. The algorithm is intended to facilitate hydrometeor discrimination. A summary of this effort is appended.

Planned efforts call for the installation of a prototype algorithm for estimating freezing levels on S-Pol and testing during an upcoming field program. Efforts to verify and improve the hydrometeor discrimination algorithm will continue with data sets from several recent field programs.

b) Planned Efforts

NSSL: Examine statistical techniques for using the data values surrounding a point of interest to help discriminate hydrometeor types. Planned efforts also call for examining a non-polarimetric method for identifying and mapping the freezing level using WSR-88D base reflectivity data.

NCAR: Install a prototype algorithm for estimating freezing levels on S-Pol and testing during an upcoming field program. Efforts to verify and improve the hydrometeor discrimination algorithm will continue with data sets from several recent field programs.

because this task deals explicitly with polarimetric issues, a new ask may need to be defined for the proposed non-polarimetric freezing level products.

c) Problems/Issues

None.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

None.

00.6.3 Circulations

Continue to enhance NSSL's Mesocyclone Detection and Tornado Detection Algorithms (MDA, TDA) while developing in parallel a new algorithm which combines MDA and TDA into one algorithm which detects and analyzes all circulations - the Vortex Detection and Diagnosis Algorithm (VDDA).

a) Current Efforts

i) Mesocyclone Detection Algorithm (MDA) implementation into ORPGA decision briefing to recommend MDA implementation into the Open Systems RPG was presented to the NEXRAD Technical Advisory Committee (TAC) on 22 August 2000. During the 4th Quarter, considerable effort was expended to provide TAC members with a 20-page briefing packet prior to the meeting. Included in the briefing package were the results of a 43-event database evaluation of both the baseline MDA and the NSSL MDA. Although the official TAC recommendations are still yet to be released, NSSL understands that the TAC has recommended MDA for ORPG implementation. Any caveats attached to this recommendation are still unknown. There was discussion during the TAC meeting about how to use information from both MDA and the Tornado Detection Algorithm (TDA) for FAA needs. This may lead to an additional task for FY01 to occur concurrently with MDA implementation. NSSL has begun work with the OSF Application Branch to develop Algorithm Enunciation Language (AEL) for the MDA.

ii) MDA/TDA Database

The new suite of students, which have been hired under separate funding to greatly expand the MDA database for the development of statistics for NWS Tornado Warning Guidance, have completed the analysis or 57 new cases during the 4th quarter. These cases represent a variety of storm types and are geographically diverse. These database efforts will be shared with the FAA in the development of circulation detection algorithms. Many of the more interesting cases in the database are given an individual analysis on the following Web page:

www.nssl.noaa.gov/teams/swat/Cases/cases_pix.html

NSSL is continuing the effort to develop a Web-based method to truth and evaluate the MDA and TDA. This will include extensive documentation and downloadable software such that NWSFO field users of the algorithms can use to develop databases similar to those developed at NSSL and add to a much larger nationwide database. We expect to release a beta version of the Web-case software in the 4th quarter. This software will be tested by NWS meteorologists at St. Louis MO, Goodland KS, and Wilmington OH.

b) Planned Efforts

Near-term efforts will be focused on the implementation of MDA within ORPG.

When VDDA work continues it is intended to develop alternate and more-robust methods to store and manage the extremely large data sets output by the simulated vortex and least-squares derivative programs.

More cases are expected to be added to the database, either by NSSL, or included from future NWSFO field office local studies.

Determine what, if any, changes may be needed in MDA/TDA to provide ITWS with better severe storm information.

c) Problems/Issues

None.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

MDA was expected to be complete before the end of FY2000. This has not occurred because MDA finalization has not proceeded as rapidly as expected. Milestone 00.6.3.E1 was to be accomplished 3 months after OSF acceptance of MDA. Because OSF acceptance is contingent upon TAC approval, this deliverable date should be reviewed once the official TAC recommendation is known. NSSL also recommends that members of OSF Applications and Engineering meet with the Open Systems teams to determine the new path of implementation in the open systems environment, and what impact that would have on NSSL SRAD resources in terms of FAA and OSF MOU staff funding.

00.6.4 Technical Facilitation

Continue to work through the process of algorithm transition to the operational WSR-88D system. This also includes development of a Common Operations Development Environment (CODE) and Application Programmer Interfaces (API's) for a more rapid integration of algorithms into the operational system.

a) Current Efforts

An interactive cross-section capability was implemented. Instead of choosing the cross-section plane and then requesting a new cross-section, the cross-section is now implemented interactively, so that the user can "fly" into the data, thus creating cross-sections on the fly. This capability is being tested. The original implementation of tables was found to not scale very well, so it was reimplemented and now performs an *order of magnitude* faster. The CODE system can now access, read and display more ORPG trend, table and raster image products.

b) Planned Efforts

c) Problems/Issues

None.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

None.

00.6.6 Rapid Update

Develop software that produces algorithm output after each tilt, thus providing immediate information to the users.

a) Current Efforts

The integration of Rapid Update within CODE is complete. Enhancements added into the SSAP code are: 1) notification (with a “T”) when a storm is topped, and 2) updating the SCIT attributes and time-height trends when a storm is topped. Storm table attributes are updated when needed, and the user is made aware of the update with an up arrow.

b) Planned Efforts

1. For MDA and TDA, the motion vector is calculated and tracking is performed after a new low-altitude single 2D feature is time-associated with an old 3D detection. The tracking results are output as they change, without any need to wait for a new volume scan.

2. For MDA, the time associations for detections whose base are above lowest elevation angle is now performed.

3. For MDA, vertical association for 2D features at ranges greater than 175 km is now performed in the same way as 2D features at ranges less than 175 km. Previously, 2D features beyond 175 km were treated as a special case, in that no vertical association was performed. These changes are implemented into the SSAP code. Follow with real time testing.

c) Problems/Issues

None.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

None.

00.6.7 Cell and Area Tracking

Integration of the Storm Cell Identification and Tracking (SCIT), the Correlation Tracking (CT) and Scale Separation (SS) algorithms into a single multi-scale precipitation tracking and forecast package.

a) Current Efforts

During September, NSSL received GDST release 3.1 from MIT/LL. The release was compiled and tested. A bug was found in one of the modules and MIT/LL was notified. The bug fix has been received and will be tested during the next month. Milestone 00.6.1.1E1 is complete.

b) Planned Efforts

Test MIT/LL bug fix. Implement the GDT I/O into CODE infrastructure.

c) Problems/Issues

None.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

As yet, it is unclear how much effort will be required to implement the GDT into CODE; milestones and/or funding may need to be reviewed.

00.6.9 Composite Products

Develop high resolution radar layer products that are rapidly updated.

a) Current Efforts

During this quarter the test of a three-dimensional radar data gridding scheme with a ground clutter and AP filter and a bright-band identification scheme was finished. All the milestones in FY00 NEXRAD Enhancements PDT Technical Direction (http://www.nssl.noaa.gov/~conway/faa/td_fy00.html) have been met. Below are a summary for the tasks associated with the milestones.

1) Prototype radar gridding procedure

A three dimensional conical to Cartesian transformation has been developed and tested for several summer (convective storms) and winter (stratiform precipitation with bright-band) cases. A multi-radar mosaic using an inverse-distance weighting function has also been developed in a Cartesian reference frame. The transformation and mosaic schemes are shown to be computationally efficient and physically consistent (See the second and third quarter reports). The schemes have been running in **real-time** for a large region in the southwest United States using a grid of **1 km x 1 km** resolution.

2) Ground clutter (GC) and anomalous propagation (AP) removal

Prior to the gridding procedure, radar data (level II) has been processed to remove residual ground clutters and anomalous propagation echoes. GC removal is based on the OSF terrain-based hybrid scans ((ref: O'Bannon, 1997: Using a 'terrain-based' hybrid scan to improve WSR-88D precipitation estimates. Preprints, The 28th International Conference on Radar Meteorology, September 7-12, 1997, 506-507). All bins below the hybrid scans have been removed. Then the reflectivity bins on the hybrid scan and the bins right above the hybrid scan are compared. If there is a discontinuity between the two consecutive bins, the reflectivity bin below is removed. The current GC and AP removal is shown to be very effective to filter majority of the residual GC's and AP's after the RDA (see examples in 2nd quarter report). Further improvements of AP removal using radial velocity data is under testing.

3) Bright-band contamination removal

A separate report (by Jonathan Gourley) describes a bright-band identification scheme using sounding and radar reflectivity data. Once bright-band is identified, it can be easily removed (or flagged for warnings).

4) Initial operational display concepts

Several display options have been tested. The first is the WDSS-II system, in which the mosaic products can be displayed in addition to many other radar products. Slicing and dicing functions will be developed for the 3D reflectivity mosaic. The second is a PC web-based environment, in which mosaic products can be displayed on the internet and updated very rapidly (e.g., real-time mosaic products are currently displayed on the web and updated every 5 minutes for the domain of Arizona). The third is the FAA's en route Display System Replacement (DSR) display where the 3D reflectivity mosaic data can be used in an air traffic control (ATC) application (which should available in a separate report by Dr. James Kelley from Mitre). All three displays have received positive feedback.

<u>b) Planned Efforts</u>

Future plans include:

1) Improve GC and AP filters by incorporating radial velocity data.

2) Develop user-defined product suites from the 3D reflectivity mosaic, e.g., VIL, echo top, layer composite reflectivities, etc.

3) Further improvements of the 3D remapping and mosaic (e.g., filling in gaps at high altitudes).

4) Data compression.

c) Problems/Issues

None.

d) Interface with other Organizations

Provided Mitre with the 3D mosaic data.

e) Activity Schedule Changes

None.

00.6.11 Volume Coverage Patterns

Develop and implement Volume Coverage Patterns (VCP's) relevant to the goals of the AWR PDT's.

a) Current Efforts

Milestone 00.6.11E1 completed as of 3rd Quarter.

b) Planned Efforts

Continue analysis and data collection on new VCP's. In particular, check that current algorithms are compatible with new VCP's, and correct any incompatibilities.

c) Problems/Issues

None.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

None

00.6.12 Product Implementation

Explore and define implementation paths within the aviation community systems that are best for NEXRAD PDT products.

a) Current Efforts

Investigation has begun with MIT/LL in their use of TDA in ITWS for identifying storms that could affect a larger than usual airspace volume. Initially, the version of TDA being used by MIT/LL appeared to generate vast numbers of clearly false alarms. However, recent inquiry has revealed that the MIT/LL suffered two problems: 1) the unfolding algorithm wasn't working properly due to the lack of a sounding profile, and 2) some of the algorithm parameters were not being initialized properly. Addressing these problems resulted in performance identical to that expected

MDA performance has not yet been evaluated. However, MIT/LL is currently running version 3.6 of the Severe Storm Analysis Program (SSAP). Version 3.10 is the current released version. Hence, any additional testing should wait until SSAP 3.10 is installed and running.

b) Planned Efforts

Coordinate new SSAP installation for MIT/LL and coordinate testing of MDA output on known cases.

Coordinate with NCAR on their freezing level identification algorithm, then present this capability to other PDT's to determine interest levels.

General contacts are also planned with other PDT leaders, to determine if the current NEPDT products are meeting their needs and what, if any, additional capabilities are needed. In particular, various SSAP parameters will be examined to determine if better severe storm guidance can be provided to ITWS.

c) Problems/Issues

None.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

As this task evolves, an additional task may need to be identified.

00.6.14 Multi-radar Composites

Develop a vision for FAA use of high resolution, rapid update, composite products which are produced from the integration of multiple WSR-88Ds.

a) Current Efforts

Activities for the fourth quarter of multi-radar composites include expanding the mosaic to use all 8 radars (KAMA, KDYX, KEWX, KFWS, KGRK, KINX, KLBB, KTLX) for the Dallas hail storm case and to construct 3D mosaic fields for a 24-h period (from 1200Z on May 5, 1995 to 1200Z on May 6, 1995) that covered the life cycle of the event. Fig. 2 shows a time series of composite reflectivity fields that are valid at 1530Z (a), 1730Z (b), 1930Z (c), 2130Z (d), and 2330Z(e)

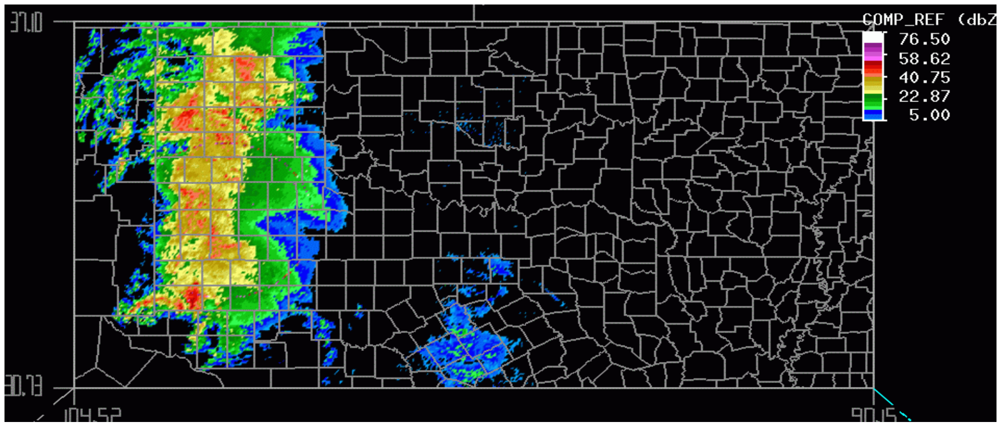

Figure 2a.Composite reflectivity field valid at 1530Z 5 May 1995.

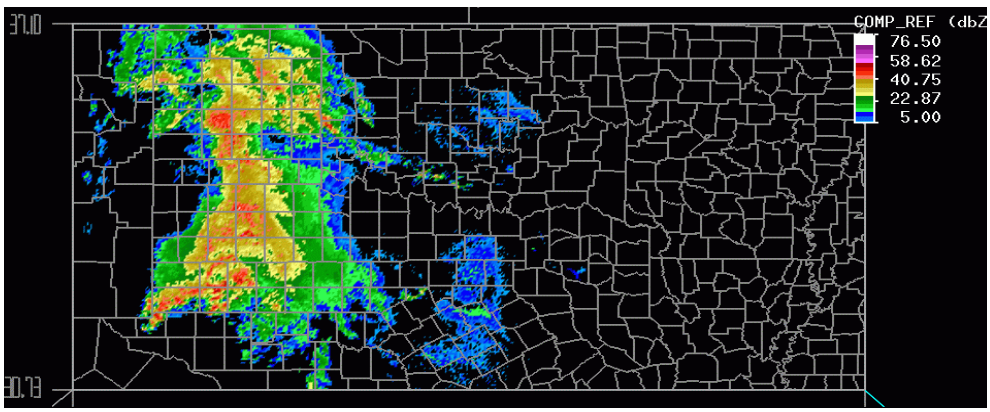

Figure 2b.Composite reflectivity field valid at 1730Z 5 May 1995.

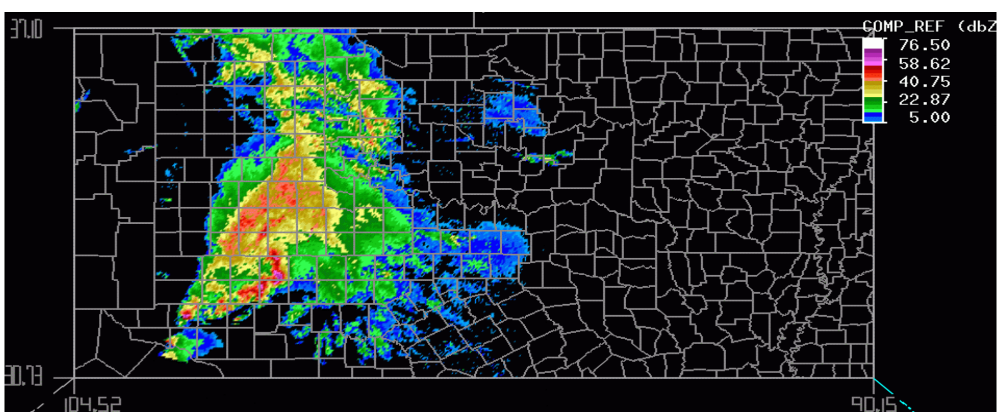

Figure 2c.Composite reflectivity field valid at 1930Z 5 May 1995.

on May 5, 1995 and 0130Z (f), 0330Z (g), and 0530Z (h) on May 6, 1995. It shows that the mosaic fields provide nice depiction of the spatial structure and the evolution of storm systems.

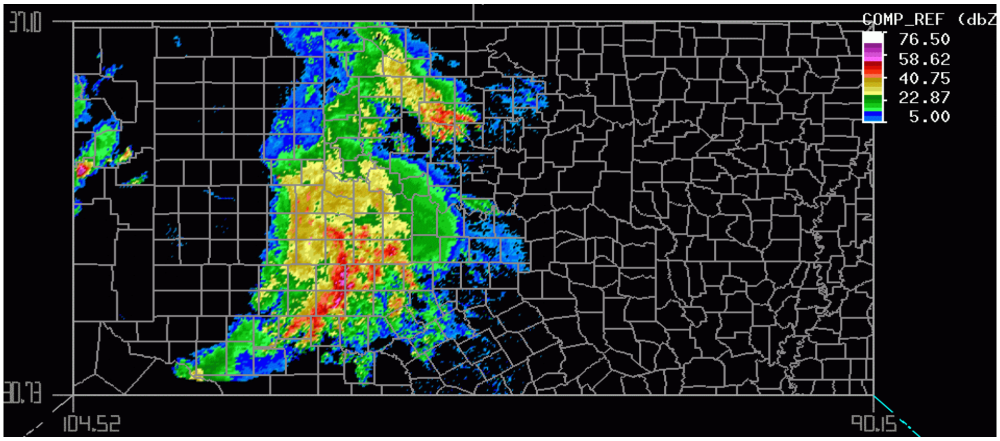

Figure 2d.Composite reflectivity field valid at 2130Z 5 May 1995.

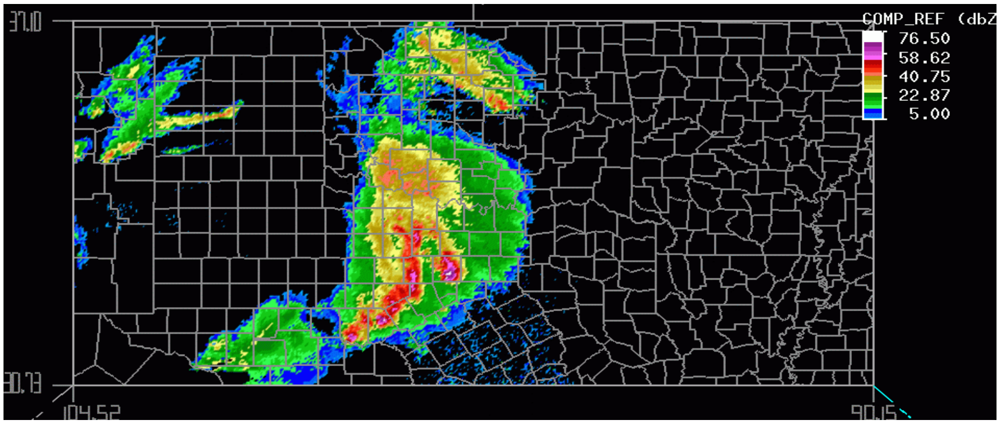

Figure 2e.Composite reflectivity field valid at 2330Z 5 May 1995.

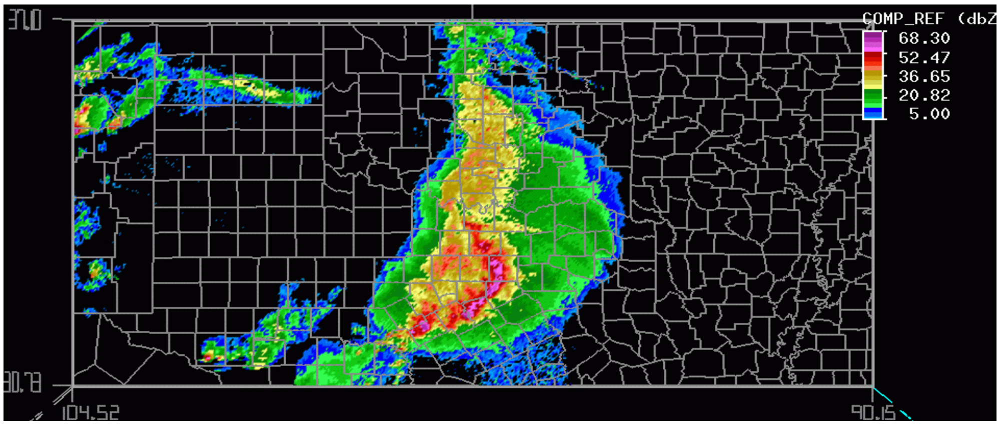

Figure 2f.Composite reflectivity field valid at 0130Z 6 May 1995.

During this quarter the test of a three-dimensional multi-radar integration algorithm (see the quarterly report for task.00.6.9) was completed. The algorithm

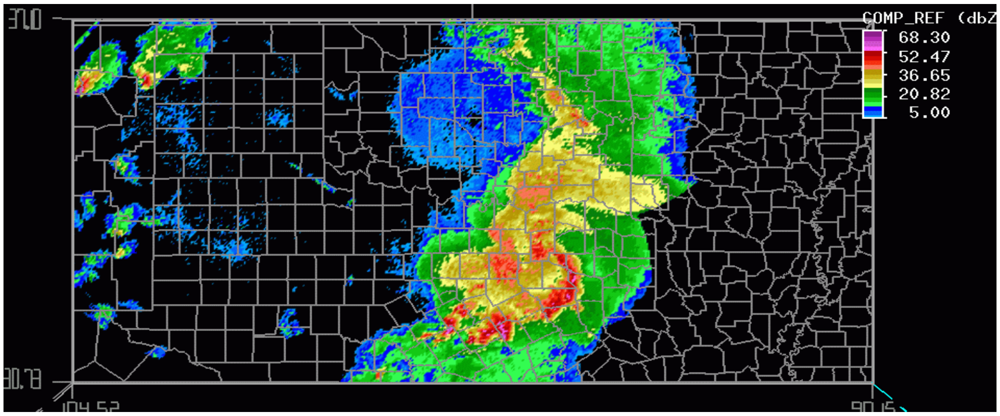

Figure 2h.Composite reflectivity field valid at 0330Z 6 May 1995.

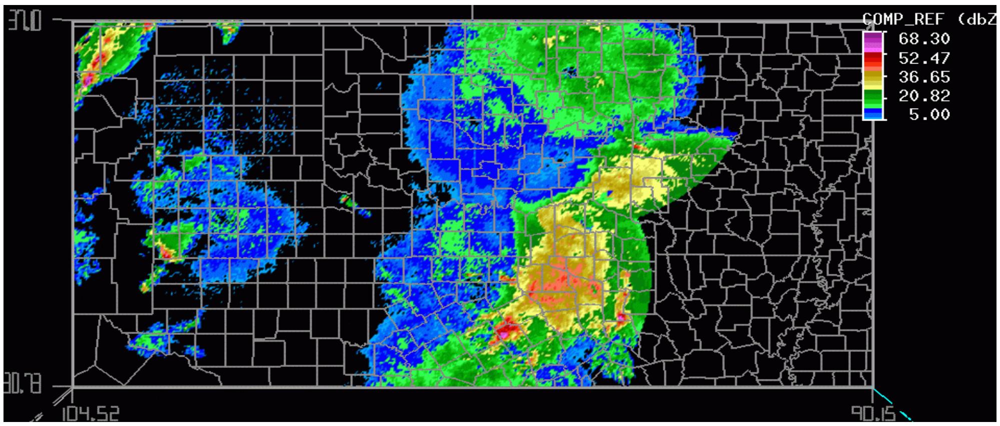

Figure 2i.Composite reflectivity field valid at 0530Z 6 May 1995.

has been presented at the FAA multi-radar integration workshop. Mitre has investigated potential uses of the 3D reflectivity mosaic data in en route air traffic control (ATC) environment and demonstrated the applications on the FAA's Display System Replacement (DSR) prototype with realistic ATC data. They found that gridded product gives controllers the flexibility they desire to define the displayed altitude stratum of most interest at any particular time. The gridded product is easy to incorporate into an ATC display application given sufficient processing resources (see separate report by Dr. James Kelley from Mitre).

b) Planned Efforts

Future plans include:

1) Further development based on FAA's requirements for multi-radar mosaic.

2) See planned efforts for task 00.6.9.

c) Problems/Issues

None.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

None.